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Powering Zambia's green growth ambitions through clean energy expansion

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Key Messages

As Zambia pursues its green growth ambitions, this policy brief highlights key insights towards a climate-compatible growth pathway:

- Powering green economic growth requires a resilient energy system that can meet growing demand. Integrated energy planning and policies that foster a low-carbon expansion of the energy sector will be key.
- Energy demands are projected to increase substantially due to increasing population and economic growth. The associated increase in greenhouse gas emissions can be moderated by expanding low-carbon electricity generation and uptake of clean fuels. This would maintain Zambia's low-carbon intensity and avoid lock-in to infrastructure for a carbon-intensive, fossil fuel powered system.
- A green growth pathway, in line with Zambia's international climate commitments, will also depend heavily on reducing emissions from land-use, land-use change, and forestry (LULUCF), as this sector is estimated to cause the majority of Zambia's current emissions. Reducing land emissions can be supported by promoting affordable and accessible clean cooking solutions.

PHOTO: RAINER LESNIEWSKI – DREAMSTIME.COM

Bus on the M10 road in Southern Zambia

Introduction

The Government of Zambia has established policies, including the National Green Growth Strategy (NGGS) [1], to guide the country towards green, inclusive economic growth and environmental sustainability as part of its vision to become a prosperous middle-income nation by 2030. Amongst other goals, the NGGS aims to address two key challenges: i) the country's vulnerability to droughts, which threaten its hydropower-reliant electricity grid and vital agricultural sector, and ii) the country's persistent energy access gaps for both electricity and clean cooking. Zambia is seeking to tackle these issues while also reducing greenhouse gas emissions. Zambia's Nationally Determined Contribution (NDC) commits to reducing greenhouse gas

emissions by at least 25% by 2030 with respect to a 2010 baseline, and by 47% with sufficient international support [2].

This policy brief aims to provide insight into how the energy system can be developed to support Zambia's green growth ambition. The transformation of the energy sector is explored through two contrasting development pathways. The Business-As-Usual (BAU) scenario depicts the continuation of historic social and economic trends, while the NGGS scenario represents a green growth pathway that is modelled to achieve the strategy's development goals and environmental objectives. Comparing these scenarios provides policymakers with insights on the required energy sector expansion and potential trade-offs to move Zambia to a more resilient growth model that continues on a low-emissions pathway.

The underlying analysis was performed to support the World Bank's Country Climate and Development Report (CCDR) for Zambia – a diagnostic report that aims to strengthen Zambia's development aspirations in the context of climate change and related commitments [3]. The CCDR presents a much broader analysis of the pathways, including, for example, assessments of climate resilience and adaptation, economic opportunities, and ecosystem services.

Research Approach

This policy brief draws insights from the scenario analysis of two contrasting development pathways for Zambia, BAU and NGGS. Scenario analyses explore potential futures to support strategic decision-making. The scenarios for this analysis were developed in consultation with a broad set of stakeholders as part of the development of the CCDR. A key aspect of such scenarios are the energy systems underpinning the development pathways and their associated emissions. To assess this, the whole energy system model OSeMOSYS-Zambia was used to analyse the underlying energy sector pathways, while other CCDR-related analyses were integrated to provide a comprehensive picture of greenhouse gas emissions across all sectors. An overview of key scenario parameters for both scenarios is provided in **Table 1**.

OSeMOSYS-Zambia is an open-source whole energy system model for Zambia [4]. The model includes a detailed representation of the Zambian energy system, covering the supply side (eg the power sector), as well as all energy demand sectors, (eg cooking, industry, and transport) [5].[1] The model was co-developed in collaboration with a number of Zambian organisations, including the Ministry of Energy and the University of Zambia, through a set of stakeholder and capacity-building workshops. It has also been used to support the development of other government strategies such as the Clean Cooking Strategy and Action Plan and finance strategy for the Integrated Resource Plan.

Beyond the energy sector, the emissions from land use, land-use change, and forestry (LULUCF) are based on CCDR analysis. Emissions from agriculture, industrial processes, and product use (IPPU) and waste are not the focus of this analysis and are projected based on historical patterns for both scenarios.

[1] OSeMOSYS-Zambia minimises the system costs to meet given energy service demands across end-use sectors, given policy objectives and different technical, environmental, and other constraints. The system optimisation is based on a detailed techno-economic characterisation of the system in terms of investment and operating costs, efficiencies, operational constraints, and other parameters describing energy infrastructure options.

Table 1: *Key overarching and energy sector-related scenario parameters for the BAU and NGGS scenario.*

	Scenario parameter	Unit	2022	2050	
				BAU scenario	NGGS scenario
Economy and population	GDP per capita	2023 US$	1371	2270	4004
	Population	Millions	19.7	37.5	37.5
Energy supply	Power generation capacity	GW	3.7	10.4	23.2
	Wind and solar capacity	GW	0.1	5.2	10.5
	Electricity access	%	48	84	100
Energy demand	Copper production	Million metric tonnes	0.7	1.75	3
	Agricultural mechanisation	%	1.7	5	50
	Clean transport	%	0	20	50

Note: More details and other parameters are provided in the CCDR [3].

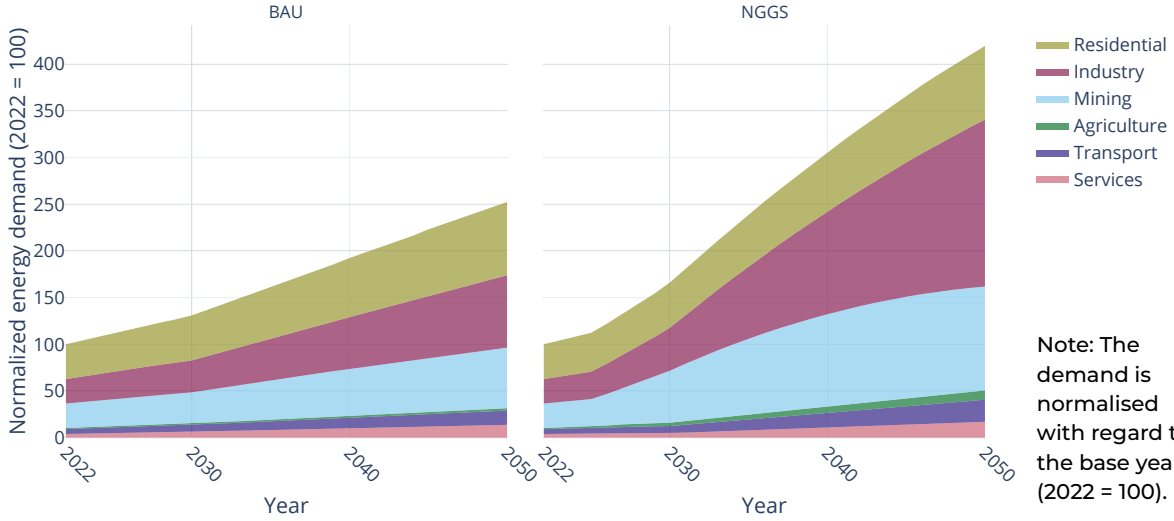
Key Insights

By charting out an NGGS-aligned green growth pathway and contrasting it with a business-as-usual (BAU) scenario, the analysis highlights several key policy-relevant insights regarding the underlying energy system pathway, and other emitting sectors.

Powering economic growth and development ambitions will require a substantial expansion of the energy sector. This will require integrated planning across energy and interlinked sectors, including land and water. Energy needs are projected to more than double in the BAU scenario and quadruple in the NGGS scenario between 2022 and 2050 (see **Figure 1**).[2] The demand growth is particularly driven by the industrial and mining sectors, both energy-intensive sectors that are key focus areas of the government's economic growth agenda.

[2] 'Energy needs' specifically refers to useful energy demand, that is, the energy actually fulfilling an end-use application (eg energy in the form of light from a light bulb).

Figure 1: *Normalised energy demand by sector for the BAU (left) and NGGS scenario (right).*



Note: The demand is normalised with regard to the base year (2022 = 100).

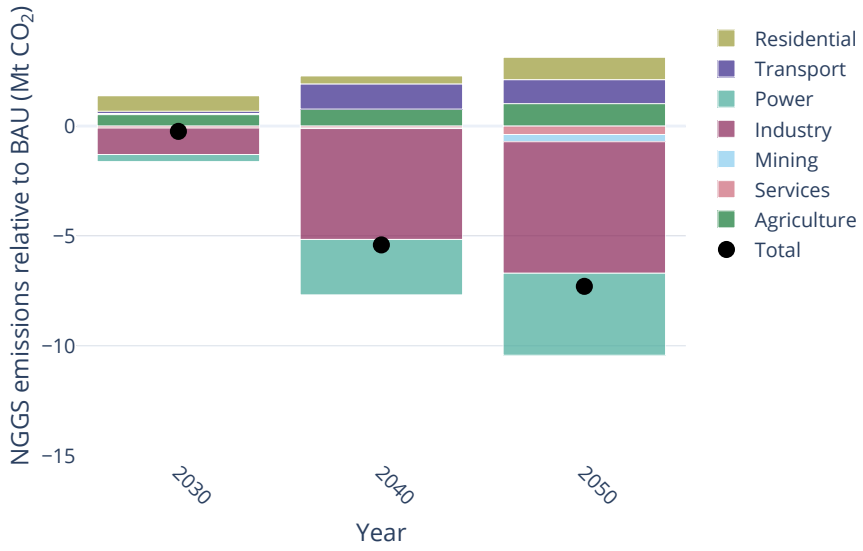
CO_2 emissions from the energy sector currently constitute a small share of Zambia's total GHG emissions (around 6% in 2022).[3] However, as strong growth is expected in the energy sector to support increased activity in mining, other industry and the residential sector, total emissions could rise rapidly. Therefore, pursuing a low-carbon pathway will be crucial to moderate emission increases from the sector, and maintain Zambia's low-carbon intensity system. Annual energy sector emissions are projected to increase from around 6 Mt CO_2 in 2022 to 43 Mt CO_2 and 36 Mt CO_2 by 2050 in the BAU and NGGS scenarios, respectively. This is largely due to the energy sector's substantial growth and its continued – and in some cases increasing – reliance on fossil fuels. This includes, in particular, coal for power generation and industry, as well as oil products in the transport sector. Under the high-growth NGGS scenario, the absence of the additional efforts to foster a lower-carbon energy system could otherwise lead to emissions of 72 Mt CO_2 by 2050.

Efforts to curb fossil fuel consumption are particularly crucial in the industry, power, and transport sectors. This includes increased deployment of renewables for power generation and increasing the share of electricity and biofuels in transport. These three sectors account for 43 Mt CO_2 or almost 99% of energy sector CO_2 emissions in 2050 under the BAU scenario. By moderating the increasing use of coal in industry and power generation, as well as by introducing alternative low-carbon fuels for transport, the NGGS scenario reduces emissions from these sectors by 9 Mt CO_2 compared to the BAU scenario (see **Figure 2**). This is despite the sectors' higher growth driven by the development ambitions underpinning the NGGS scenario (see **Figure 1**). In the power sector, this is underpinned by a diversification of the sector with a much stronger build-up of solar and wind power. This shift also addresses other policy ambitions of the NGGS scenario, including resilience to droughts.

Driven by strong economic growth, demand for transport is projected to surge, nearly doubling passenger and freight activity by 2050 under the BAU scenario, and tripling under the NGGS. While the NGGS incorporates measures to mitigate this impact, such as modal shifting from road to rail

[3] Note: for the energy sector, this analysis captures CO_2 emissions only. For other sectors, non-CO_2 emissions are also captured.

***Figure 2:** CO_2 emissions from the energy sector in the NGGS scenario relative to the BAU scenario.*



and adopting electric vehicles, this increase in demand means that transport emissions are projected to rise from 2.2 Mt CO_2 to 6.3 Mt CO_2 between 2022 and 2050, even higher than the 5.2 Mt CO_2 projected in the BAU.

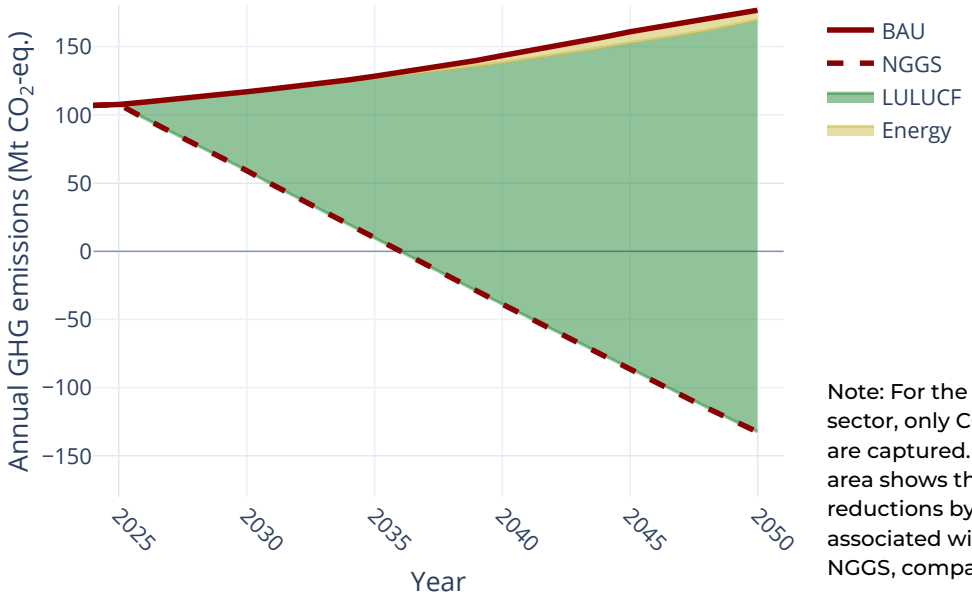
The proposed biodiesel mandate[4] in the NGGS can reduce fossil fuel dependency, cutting diesel imports by 150 ktoe/yr and emissions by 400 kt CO_2 by 2050, if biodiesel is assumed to be carbon neutral. Indeed, this strategy depends on creating a viable domestic sector capable of sustainably growing feedstock crops (eg 850 kt of new soybean) and refining it locally. A broader biofuel strategy that also includes bioethanol could double these benefits, reducing petrol imports by an additional 174 ktoe, or around 5%, and emissions by an additional 500 kt CO_2.

The high-growth NGGS pathway substantially increases investment requirements for energy infrastructure but also leads to positive ripple effects on the wider economy. Due to higher energy demand and more capital-intensive renewable technologies, the NGGS scenario sees cumulative investments of around 16 billion USD (in 2015 prices) in power generation between 2022 and 2050, compared to the lower BAU requirement of 6 billion USD. While securing this additional investment will be challenging, investments in the energy system are also likely to have positive impacts on the wider economy, including household income [6].

If efforts to reduce emissions from land use, land-use change, and forestry (LULUCF) remain limited, annual GHG emissions are expected to increase substantially as the Zambian economy and population grow, irrespective of efforts in the energy sector. LULUCF emissions are currently the dominant source of GHG emissions. Therefore, achieving significant emission reductions in a green growth pathway will largely depend on this sector. In 2022, emissions from the LULUCF sector made up 66% of Zambia's total GHG emissions (70 Mt CO_2eq). In the BAU scenario, emissions from this sector are assumed to increase based on historic patterns, driving an increase in total GHG emissions from around 107 Mt CO_2eq in 2022 to 177 Mt CO_2eq in 2050 (see **Figure 3**).

[4] The NGGS sets out a target of 5% for the biodiesel share in petroleum products by 2030.

Figure 3: *Territorial GHG emissions from all emitting sectors in the BAU and NGGS scenarios.*



Note: For the energy sector, only CO_2 emissions are captured. The wedge area shows the emission reductions by sector associated with the NGGS, compared to BAU.

In contrast, in the NGGS scenario, strong efforts to reduce forest loss and restore degraded lands lead to LULUCF emissions turning negative, leading to the country becoming a net GHG sink around 2036. In the NGGS scenario, annual GHG emissions reduce steadily, reaching 58 Mt CO_2eq by 2030 (see **Figure 3**). This is roughly in line with Zambia's climate pledge with limited international support, highlighting that the type of actions in the NGGS are required to meet the NDC target[5].

Transitioning to clean cooking solutions – currently dominated by the inefficient use of traditional biomass and charcoal – is also crucial to supporting emission reductions in the LULUCF sector. Due to population growth and urbanisation, gross GHG emissions from the use of biomass for cooking, including charcoal, increase from approximately 20 Mt CO_2eq in 2022 to 40 Mt CO_2eq in 2050 in the BAU scenario. In the NGGS scenario stove emissions are reduced to around 17 MtCO_2eq in 2050. This is achieved through the phase out of charcoal use in urban areas, the shift to improved cookstoves in rural areas, and the use of clean fuels. Forest sequestration offsets part of these emissions wherever biomass is produced sustainably. Nevertheless, this underlines the major impact a shift to more efficient stoves and a phase out of charcoal use can have on emissions.

[5] Please note that this is derived by applying the fraction of emission reduction from Zambia's NDC to the emissions for 2010 as reported by ClimateWatch [7]. Thus, this might not be in line with absolute numbers based on official accounting used in the NDC.

Conclusions

Zambia's energy system faces several challenges in becoming a resilient engine for equitable and green economic growth. This includes, among others, a diversification of power generation for drought resilience, on- and off grid electrification, and wider access to clean energy, as well as financing to address these issues and a strong expansion of the energy sector.

This policy brief starts to chart out the contours of an energy system pathway that could meet Zambia's green growth ambitions and highlights the need for further analyses to support integrated planning and policy that addresses these challenges and puts Zambia firmly on a green growth pathway.

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